# Biogenic Trace Gas Emissions in the United States

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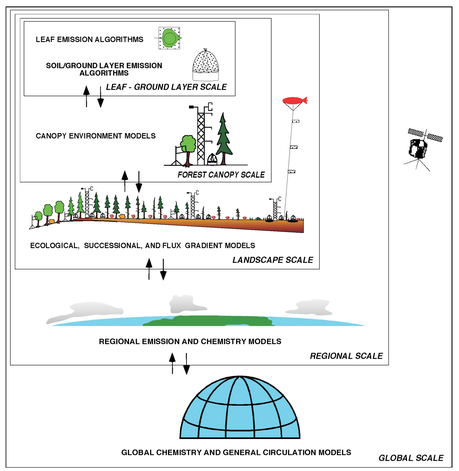
Biogenic volatile organic compounds (BVOCs) are emitted from natural and agricultural sources such as forests and crops. They are typically very reactive and are often considered to be important factors in determining air quality in many regions of the United States. Although they are not usually considered pollutants themselves, they often react with anthropogenic emissions such as nitrogen oxides to form smog. Therefore accurate estimates of BVOC emissions are needed to develop effective air pollution control strategies. Emission models are constructed from data collected at leaf to plant levels, and then "scaled up" to regional and global levels as shown below.

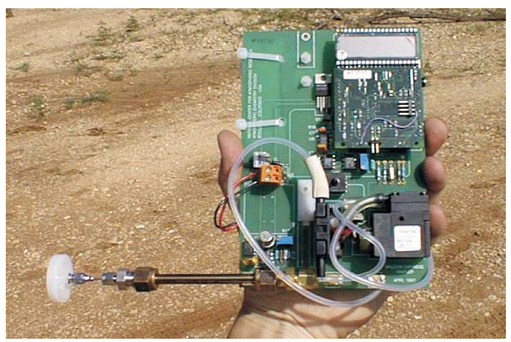
**HIERARCHY OF METHODS AND MODELS USED IN BIOGEOCHEMICAL CYCLING RESEARCH**




Major vegetation species are tested for BVOC emissions rates under a range of sunlight, temperature, and humidity levels. In the United States, BVOC emissions are dominated by isoprene from oak and poplar trees, terpenes from conifers, and oxygenated compounds from crops and grasslands.

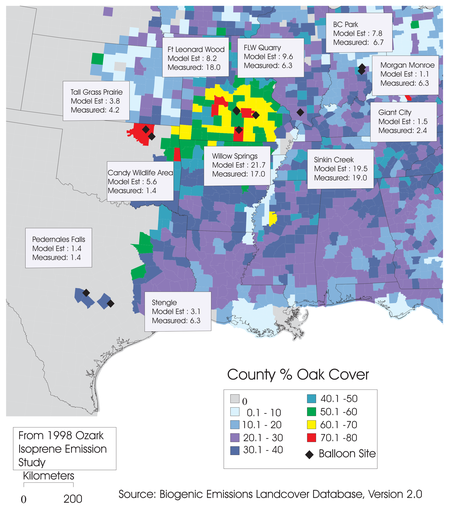
Vegetation enclosures and portable field instrumentation allow us to test dominant plant species for emission rates of various BVOCs. By measuring emissions non-destructively in the plant's natural environment, we can develop more realistic emission factors for these compounds under a range of environmental conditions.

Tethered balloons are used to deploy meteorological sensors and trace gas sampling cartridges (below). Atmospheric concentrations of BVOCs are used to estimate emissions at scales of several 100 km$^2$, which are useful for model comparisons.



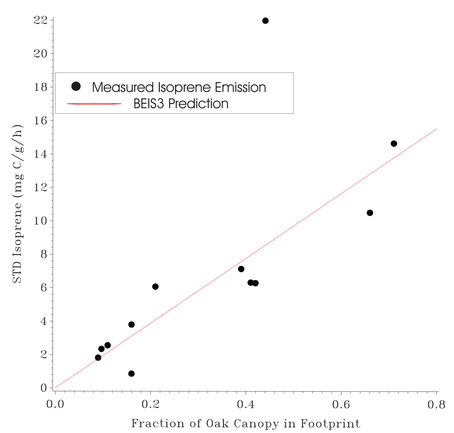
In the Summer of 1998, a study sponsored by EPA (NRMRL and NERL) was conducted in the central United States to test EPA BVOC emission models. The Ozark Mountains in Missouri and Arkansas are thought to be one of the largest isoprene source regions in North America. Transport from this region is thought to be important in controlling air quality in many midwestern locales (including the St. Louis and Chicago airsheds). Using leaf-level and landscape-level measurements discussed previously, combined with aircraft measurements of BVOC and other compounds, we are able to test the validity of ORD's Biogenic Emission Inventory System, Versions 2 & 3(BEIS2/3) in this region.

## Model Estimates of Isoprene Emission vs Measured



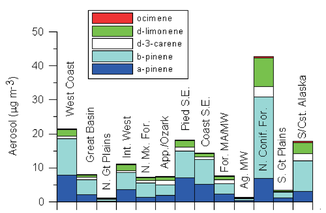

Source: Biogenic Emissions Landcover Database, Version 2.0

Although data from this study are still being analyzed, results thus far indicate that emission models capture the variability in isoprene emissions measured by aircraft and tethered balloons quite well. Model estimates and measured emission comparisons at individual sites within the study region are shown above. The magnitude of these emissions also agrees quite well with model estimates, also illustrated graphically below.




## Conclusions

EPA biogenic emission models and inventories are important in determining natural contributions to ambient VOC levels and reactivity. Model estimates for the Central U.S. compare favorably with real-world data from a high-isoprene source region in and around the Ozark Mountains. This has also been demonstrated in the southeastern U.S. Further research is being conducted to develop and improve components of the modeling system which account for BVOCs that form aerosols upon reaction with other atmospheric compounds. These compounds include monoterpenes and other compounds which can form organic aerosols. Preliminary results, shown below, suggest that under certain conditions, aerosols composed of BVOC reaction products can account for significant atmospheric loadings.




These studies and those investigating relationships between BVOCs and global change are being conducted at EPA's new RTP facility and at nearby field sites such as the Duke University Free Atmosphere Carbon Transfer Scheme (FACTS, shown below) where exposure of the forest canopy to carbon dioxide is manipulated to simulate future conditions.

## Impacts

These studies support recent hypotheses that biogenic isoprene is emitted in quantities large enough to impact air quality policy decisions in the United States. When scaled to annual estimates, BVOC emissions exceed anthropogenic VOC emissions in the U.S. In addition, BVOCs are more reactive and are emitted primarily in warm summertime conditions when smog formation is most difficult to control. These scaling studies, when compared to BEIS2/3 emission model output, provide evidence that EPA emission models and inventories compare reasonably well.